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# SKETCH MAP of NORTH EAST INDIA

## SHOWING TEA AREAS

*Scale 1 inch=32 Miles*

50 40 30 20 10 0 50 100 Miles

N

SIKKIM
BHUTAN
NEPAL
DARJEELING
Kurseong
Siliguri
Jalpaiguri
Barnes
DOOARS
B.D.R.
Teesta R.
E.B.R.
Cooch Behar
Dhubri
Lalmanirhat
Parbatipur
Santahar
Goalundo
GANGES or PADMA R.
CALCUTTA
HOOGHLY R.
BAY OF BENGAL
BRAHMAPUTRA R.
Gauhati
A.B.R.
DARRANG
Silghat
NOWGONG
MIKIR HILLS
GARO HILLS
KHASIA HILLS
JAINTIA HILLS
Shillong
Cherrapunji
Lumding
SYLHET
Sylhet
Badarpur
CACHAR
Silchar
Chand pur
HILL TIPPERAH
CHITTAGONG HILL TRACTS
LUSHAI HILLS
Aijal
LAKHIMPUR
Sadiya
Dibrugarh
Jorhat
Sibsagar
Ledo
NAGA HILLS
Imphal
MANIPUR
BURMA

### REFERENCES

- Hills
- Tea areas
- Railways
- Assam boundary

# SOIL SURVEY.

## Notes on the New Alluvium of the Dooars.

P. H. Carpenter, F.I.C., F.C.S.

H. R. Cooper, B.Sc., F.C.S.

In a previous note (*Quarterly Journal*, 1921, Pt. IV) Carpenter dealt with the soil types occurring on the Red Bank areas. The present note gives a brief account of the newer alluvial soils which make up the lower lying tea lands of the Dooars.

*Mal District.* In the Mal District the Red Bank forms a rough triangle with its boundaries including Lower Fagu, Meenglass, Nedeem (out-garden of Sylee) to the north-west and west, Rungamuttee and part of Hahaipatha to the south, and Toonbari with parts of Soongachi and Nakhati to the east and north-east. Outside this area the Mal District consists of newer alluvium. West of the Red Bank area the soil is remarkably even in character, and is an extremely interesting type of soil. It is characterised by a sand content between 50% and 80% (coarse sand nearly always being in excess of fine sand) and a clay content averaging about 3%, being sometimes under 1% and practically never above 8%. The place of clay (which is generally the "binding" constituent of a soil) is apparently taken by colloidal organic matter which is abnormally high for such light soils. "Loss on ignition" averages about 6%, being always above 4% and often up to 8%. The "soluble humus" or "Grandeau" organic matter is also remarkably high. The soils are chemically very rich and show a very high acidity by whatever method that is measured.

Mann apparently included all the Dooars new alluvium under the term "grey sandy loam." These particular soils have so little clay or even fine silt that they certainly cannot be called "loams", and the colour is often a reddish rich dark brown—almost chocolate. To distinguish this particular class of soil we propose to term it the

"*Mal Sand*". Similar soils are found in small areas in other parts of the tea districts of North East India. This sand is certainly much older than other soils of the new alluvium. It has not accumulated its organic matter and acidity in a short time. It is often very undulating, and near the hills forms high plateaux through which the rivers have cut very deeply.

At Upper Fagu similar soils occur, raised well above the level of the Red Bank, which have an organic matter content of 14%, a figure usually only found so great in bheel soils. It is possible that similar soils occur elsewhere in the hills whence they are washed down to enrich the Mal Sands.

The Mal Sand occupies a sweep of country from the Teesta River as far east as a line through Sylee, Sissubari (Good Hope), Kumlai, Baintguri, and is found again eastwards, in the southerly part of the Chalsa District.

West of the Teesta at the only garden from which analyses are available (Dangua Jhar) very similar soils are found.

The commonest soil type among the Mal Sands is the 1, 2, 4, 3, 5, which preponderates at Bullabarrie, Sylee, Leesh River, Ranicherra, Good Hope, Bagracote, Baradighi, Ellenbarrie and is also found on other gardens.

Analyses of light, average and heavy examples of the 1, 2, 4, 3, 5 type are given below :—

| | Light. | Average. | Heavy. |
|---|---|---|---|
| 1. Coarse sand ..... ... ..... | 67 | 55 | 33 |
| 2. Fine sand ..... ..... ..... | 17 | 19 | 28 |
| 3. Silt ..... ..... ..... | 2 | 8 | 11 |
| 4. Fine silt ..... ..... ..... | 5 | 10 | 13 |
| 5. Clay ..... ..... ..... | 0·1 | 4 | 10 |
| Loss on ignition (organic matter) ..... | 6·7 | 4·6 | 4·9 |
| Soluble humus (Grandeau Organic matter) ..... ..... ..... | 4·4 | 2·1 | 2·4 |
| Acidity ..... ..... ..... | 3430 | 2500 | 2270 |

Less common types, examples of which are given below also occur. It will be noticed that these are closely related to the 1,2,4,3,5 type.

| Soil Type. | 1,2,3,4,5. | 1,2,3,5,4. | 2,1,3,4,5. | 2,1,4,3,5. | 1,4,2,3,5. |
|---|---|---|---|---|---|
| 1. Coarse sand ..... | 35 | 47 | 22 | 26 | 62 |
| 2. Fine sand ..... | 20 | 25 | 45 | 37 | 10 |
| 3. Silt ..... ..... | 15 | 11 | 15 | 10 | 4 |
| 4. Fine silt ..... | 13 | 4 | 8 | 12 | 15 |
| 5. Clay ..... ..... | 7 | 5·5 | 3 | 9 | 2 |
| Loss on ignition (Organic matter) ..... | 6·0 | 5·7 | 4·1 | 4·7 | 6·0 |
| Soluble humus (Grandeau) Organic matter) | 2·5 | 3·1 | 3·2 | 1·6 | 2·9 |
| Acidity (modified Veitch Albert) ..... | 2500 | 2690 | 1600 | 1700 | 2400 |

It will be noticed that all these types have in common the following physical characteristics :

(1) Very high percentage of sand :

(2) Low clay content.

Such coarse-grained soils can lift water by capillarity through a small height only—say, 10 feet. On such soils liability to suffering from drought is therefore very great during the dry season, particularly in the Dooars where early rain is not commonly obtained. In order that tea may be safe from drought, it is therefore necessary that the distance between the deepest roots and the cold weather water-level must be less than 10 feet. To ensure this, it is essential that the depth of the root shall not be limited by a high water-level in the rains ; and to keep the rains water-level down, deep drainage will be required, except on low-lying spots where the cold weather level remains high.

Close drainage, however, is not only unnecessary but undesirable, since it dries out the soil in the dry season.

The necessity for deep roots should also be borne in mind, when deciding the early pruning treatment of tea on such soils. Bushes should be allowed a good run before pruning or plucking in order to be allowed to force down a deep straight root.

Of the Mal Sands those with the higher clay content will usually be found to do better, merely because they will be able to lift water by capillarity from a greater depth, while the rate of movement of water through the soil being slower, the rate of drying of the soil will be reduced. Where, as is nearly always the case, the clay is very low, high percentages of fine silt and organic matter (much of which is of a colloid nature) will assist to increase the power of lifting water by capillarity.

It is noticeable that wherever this very light type of soil is found, there serious attack by mosquito blight was early noticeable ; and it is very probable that this may be associated with weakening of the bush by suffering during droughts.

In only two cases, both far removed from sources of infection, are such soils known to be unattacked by mosquito.

Just below the Red Bank area, heavier soils are found, for example, at New Glencoe, and the lower parts of Hahaipatha and Sungachi, soils of the 4, 2, 3, 1, 5 ; 4, 1, 3, 2, 5 ; and 3, 1, 5, 2, 4 types are found.

To the south also the soils begin to get heavier. At Oodlabari for example while the soil type is still 1, 2, 3, 4, 5, the clay content rises from an average of about 3% over the greater part of the district, up to over 9%. At Baintguri also the clay content has risen, in this case sufficiently to exceed the fine silt, so that the soil type becomes 1, 2, 3, 5, 4.

As far south as Nowera Nuddy while sandy soils do occur, much heavier soils show, for example, the 2, 4, 3, 1, 5 and the 4, 2, 3, 1, 5. These belong more properly to the grey sandy loams, and are clearly much newer deposits than the Mal Sands, since they are much less acid, contain considerably less organic matter, and are chemically less rich. For example the loss on ignition and " soluble humus " are only about 3·5 and 1·3 respectively, while acidity is

about 1300. Physically, however, these soils containing little coarse sand or clay are probably the very best for tea, and their chemical properties may be improved by art.

At Ellenbarie there occurs a patch of whitish silt, overlying the normal Mal Sand of the garden. It only occurs in the low part of the garden near the river and even there mainly fills up hollows. This soil is of the 2, 3, 4, 5, 1 type.

It clearly bears no relation to the normal soil of the district but is a much newer deposit, similar to some of the soils found at Nowera Nuddy, and also to soils found in the Daina Toorsa and particularly the Toorsa Jainti district. This soil is characterised by low acidity and low organic matter content.

*Chalsa District:* This is almost entirely a Red Bank district. To the west the Red Bank falls steeply to the Neora river. To the east occur strips of soil along the banks of the Murti, below the Red Bank, which have been more recently deposited by that river.

Such strips occur at Yong Tong, Chalsa, and Killcott.

At Yong Tong and Chalsa the soils are clearly much newer deposits than the Mal Sands.

At Yong Tong soil of the 1, 3, 2, 5, 4 type is accompanied by 60% small stones consisting largely of unweathered shaly sandstone.

Organic matter and acidity however are high, the soil has many of the characteristics of the Mal Sands and is probably from a similar source. The same type is found further down the Murti at Chalsa. Here the percentage of stones is only 18%, while organic matter and acidity are still higher than at Yong Tong. Still further down the Murti, at Killcott, the percentage of stones becomes only 7% and the soil is of the type 1, 2, 4, 5, 3. The acidity and the organic matter are high, the clay fraction forms less than 6% and the soil as a whole bears a very marked resemblance to the Mal Sand.

South of the Red Bank absolutely typical Mal Sand occurs. From the lower part of Sathkya we have two examples of the 1, 2, 3, 5, 4 type. Although the clay slightly exceeds the fine silt

(as at Baintguri), the clay is only about $3\frac{1}{2}\%$ and the sand exceeds $70\%$. Organic matter and acidity are very high.

Examples of the very closely related 2, 1, 3, 5, 4 type also occur at Sathkya.

Further south at Baradighi the soil is of the characteristic Mal Sand type 1, 2, 4, 3, 5. Acidity and organic matter are very high and the soil resembles that of the Mal District in every respect.

*Representative analyses of new alluvium of Chulsa District.*

(Note resemblance to Mal Sands).

| Tea Gardens. | Yong Tong. | Chulsa. | Killcott. | Sathkya. | Baradighi. |
|---|---|---|---|---|---|
| Soil type. | 1,3,2,5,4. | 1,3,2,5,4. | 1,2,4,5,3. | 1,2,3,5,4. | 1,2,4,3,5. |
| 1. Coarse sand ..... | 51 | 34 | 41 | 62 | 55 |
| 2. Fine sand ..... | 11 | 22 | 30 | 16 | 31 |
| 3. Silt ..... ..... | 14 | 23 | 5 | 9 | 1·5 |
| 4. Fine silt ..... ..... | 6 | 4 | 12 | 1 | 3·5 |
| 5. Clay ..... ..... | 9 | 10 | 6 | 3 | 0·5 |
| Organic matter (Loss on ignition) ..... | 6·5 | 6·2 | 5·5 | 7·5 | 6·5 |
| Soluble humus (Grandeau organic matter) ..... | 3·0 | 3·6 | 2·0 | 4·3 | 3·1 |
| Acidity .... ..... | 1780 | 3420 | 2910 | 2840 | 2150 |

*Nagrakata District.*—The Nagrakata District also is mainly occupied by a block of Red Bank soil practically as far south as the railway.

To the west there is a flat at Hilla below the Red Bank along the bank of the Jiti River, but no analyses are available. To the south, sandy soils both of the Mal type and of the newer deposits of grey and white silts and silty sands occur.

The sandy soil at Grassmore generally is of the Mal type. The single analysis available shows the soil to be of the characteristic 1, 2, 4, 3, 5 type. While in other respects the resemblance to the Mal Sands is complete this example has a clay content about $10\%$, much higher than is usually found in the Mal District.

To the south the Jaldhakar and Daina rivers approach each other very closely, before joining. Between them is a strip of land which clearly has been deposited by these rivers within comparatively recent times. The soils are whitish or grey in appearance, and probably represent the kind of soil described by Mann as grey sandy loam. On this strip are the gardens Tondoo and Bamandanga.

As they must have been laid down at different times by flood waters moving at various rates, so the soils vary in physical composition. The water was never stagnant, so that clay is generally conspicuous by the small proportion in which it occurs. Coarse sand also is seldom present in quantity since the flood water rarely travelled fast enough to carry coarse sand in suspension. Fine sand however generally forms a great proportion of the soil.

The lightest type found is the 2, 1, 4, 3, 5 and the heaviest 4, 2, 3, 1, 5.

The average soil would appear to be 2, 3, 4, 5, 1. The type 3, 2, 4, 5, 1 and related types also occur. The subsoils are generally lighter than the top soils, the coarser particles having been dropped first.

*Representative analyses of New Alluvium of Nagrakata District.*

| Tea Gardens. | Older alluvium resembling Mal Sands. | | Very recent alluvium (grey sandy loam.) Note low sol. humus and acidity. | | | | |
|---|---|---|---|---|---|---|---|
| | Grassmore. | Chengmari. | Tondoo and Bamandanga. | | | | |
| 1. Coarse sand ..... | 32 | 37 | 1 | 4 | 26 | 4 | 1·5 |
| 2. Fine sand ..... | 24 | 12 | 20 | 30 | 39 | 46 | 62 |
| 3. Silt ..... | 11 | 12 | 23 | 33 | 14 | 23 | 17 |
| 4. Fine silt ..... | 16 | 15 | 36 | 23 | 15 | 21 | 10 |
| 5. Clay ..... | 10 | 13 | 15 | 6 | 2 | | |
| Organic matter (loss on ignition) ..... | 7·5 | 10 | 5·5 | 3 | 3 | 6 | 9·5 |
| Soluble humus (Grandeau organic matter) ..... | ..... | 4·1 | ..... | ..... | 0·9 | 1·3 | 0·7 |
| Acidity ..... | ..... | 3100 | ..... | ..... | 1100 | 990 | 840 |

*Dina Toorsa Distrtct.* The district as a whole is marked by very great variation of soil even over small areas. The comparative regularity of soil type seen in the more easterly districts changes to a collection of patches of soil physically unrelated to each other.

The only feature common to any large number of soils of the district is that all five soil fractions are generally well represented. One very seldom finds soils with any one of the five fractions present in either excessively great or excessively small quantity.

That is to say the soils are distinguished by comparatively even grading.

The district is more gently and evenly sloping, less undulating, and has been much more subjected to irregular new deposits from rivers and floods than the Western Dooars.

On the whole fine silt forms the largest fraction of the average soil, while clay occupies a prominent position in the analyses of a few gardens only. Fine sand is very commonly an important fraction, while coarse sand is frequently found in quantity over small areas.

With the exception of patches of very new deposits which are unsuitable for tea, and of less new deposits on which tea is difficult to establish, the district on the whole is very fertile. The less fertile patches are distinguished by extreme deficiency in organic matter as determined by Grandeau's method (soluble humus).

For convenience the district may be considered in three areas (1) The Daina to the Rehti ; (2) East of the Rehti up to the Hantapara plateau ; (3) the Hantapara plateau.

*Daina to Rehti.*—Just across the Daina, for example at Red Bank Tea Estate, the soils found are of the same types as are found further west.

The average soil is the very rich humus-sand such as forms the greater part of the Mal District. The only analysis available is of the very light 1, 2, 3, 4, 5 type. Probably the rather heavier 1, 2, 4, 3, 5 also occurs as in the Mal District. Rising gently above

this sand are low teelahs of undoubted Red Bank soil of which no analyses are available.

It is possible that the clay found in the soils immediately south of this area, has arisen from erosion of Red Bank soils.

Probably similar soils occur on immediately neighbouring gardens which have not been sampled.

At Red Bank Tea Estate appears a patch of infertile new white soil such as is frequently found east of the Rehti. This has clearly been deposited very recently by one of the streams of the Daina. The dark fertile sand frequently appears as "islands" slightly above the level of the infertile white sand.

The Daina and the Rehti, although afterwards diverging, rise very close to each other in the north and between them no other river comes direct from the hills. With the exception of the one patch mentioned. therefore, infertile new deposits are not found within this area, since such deposits apparently come direct from the hills.

Starting from north to south we find the soil varying without regularity.

At Chamurchi two distinct types of soil occur, the lighter 2, 4, 1, 3, 5 and the heavier 4, 3, 2, 5, 1.

Choonabhutti averages the 4, 3, 5, 1, 2 type which is related to the heavier type at Chamurchi. At Choonabhutti the following types also occur 3, 4, 1, 2, 5 and 4, 5, 3, 1, 2.

At Hortalguri (New Dooars) the very unusual silt-sand type 3, 1, 2, 5, 4 occurs over a large area, and the related types 3, 2, 5, 1, 4, and 3, 5, 2, 1, 4 occur again to the south-west at Rheabari. These are among the few cases in this district where one of the soil fractions (in this case fine silt) is present in remarkably small quantity. The other unusual character shown by these soils is that silt is present in greater quantity than any of the other fractions.

Due south of Hortalguri at Palashbari we have soils, absolutely unrelated to the Rheabari soils, of the sandy types 1, 2, 3, 4, 5 and 4, 1, 2, 3, 5 the latter being related to the 4, 1, 2, 5, 3 found

westward at Lakhipara. This Lakhipara soil however contains 17 % clay, and is distinctly a loam and not a sand, while the average soils of Lakhipara are still heavier, such as the types 4, 2, 5, 1, 3 and 4, 5, 3, 2, 1.

South of Lakhipara we have the very similar soils of Gandrapara averaging 4, 5, 3, 2, 1, the heaviest being 4, 5, 3, 1, 2 and the lightest 1, 4, 2, 5, 3.

East of Gandrapara on the gardens of the Banarhat Company occur light and light medium soils mainly of the 1, 2, 4, 5, 3 or closely related types *e. g.*, 1, 2, 4, 3, 5 ; 1, 2, 3, 4, 5 ; 2, 1, 4, 3, 5 ; heavy medium soils 4, 2, 1, 5, 3 with related types 4, 2, 1, 3, 5 and 2, 4, 1, 3, 5, and 1, 4, 5, 2, 3 ; and one example of a heavy clay soil 5, 4, 2, 1, 3.

Further south at Binnaguri occur soils of the very heavy type 5, 4, 3, 2, 1 with related types 5, 4, 3, 1, 2 ; 5, 4, 2, 3, 1 and 4, 5, 3, 2, 1 together with sandier soils 1, 5, 3, 2, 4 and patches of very light soil of the 1, 2, 5, 4, 3 type overlying stones.

A little west of Binnaguri Station the railway makes an abrupt turn and then runs a little north of south-east. Below this line the soils show a distinct change. A line through Lakhipara, Gandrapara, Binnaguri goes mainly through heavy soils. The soils southward become sandier, the predominant types being 1, 4, 2, 3, 5 at Huldibari, 1, 3, 5, 2, 4 at Telipara, while from Gairkhata we have a single analysis showing a soil type 1, 2, 5, 3, 4. It is in this area that streams arise, and the assumption is made that they have been running under the more northerly heavy surface soils, through easily premeable stony and sandy subsoils, till they arrive at the flatter and more sandy land.

If this is true, the subsoils north of the railway must be very permeable to water, and this fact might be made use of in the drainage of the gardens. "Blind" drains, so long as deep enough to reach the natural underdrainage, should be all that is necessary. If the permeable subsoil is too deep to be reached by drains, then it may be possible to drain into "sumps," which empty through the subsoil, as the underground rivers are presumed to do.

East and south of Gairkhata the land is flat, cut up by many streams, and mainly under rice.

The second area from the Rehti up to the Hantapara plateau is still largely under jungle, and few gardens have been systematically sampled. Very many of the samples received have been sent in because tea has done very badly on certain patches, and these bad patches only have been analysed.

The infertile patches are concentrated in this area which is cut up by many rivers and streams direct from the hills. They generally occur as heavy silts, the 4, 3, 2 type with the related 4, 2, 3 ; 3, 2, 4 and 2, 3, 4 being common, but cases of 2, 1, 3 and even the very sandy 1, 2, 3 occur. Whatever the heaviness of these soils they are always white or grey in colour, alkaline in reaction, and very deficient in organic matter. Here it need only be pointed out that they are clearly new diposits of material straight from the hills, occur among the tea districts proper in patches only, and do not represent the greater part of the gardens on which they are found.

In the Daina-Toorsa district examples occur so widely distributed as Red Bank Tea Estate, Dheklapara, Jaybirpara, Makrapara, Dalmore, Nangdala. Further south occur patches which though not alkaline, are of low acidity and low organic matter content. They are of similar appearance but have become darker. These patches grow tea but not with the luxuriance of the more normal soil of the district. These patches are probably of similar origin to the more northerly alkaline patches but have been longer *in situ*, while the normally fertile acid soils of the district, characterised by a high content of organic matter, may be of similar origin but have been subjected to washing by the heavy rainfall, and have subsequently accummulated jungle residues, over a very long period.

The normal soils of the districts have not yet been very thoroughly sampled.

At Bundapani the sandy silt types 2, 1, 4, 3, 5 and 3, 2, 1, 4 5 are in evidence.

From Nangdala we have a single example of the type 2, 4, 3, 5, 1. This and allied types, where the percentage of either clay or coarse sand is small, appear to be the characteristic soils of the area. Having little clay, little resistance is offered to passage of water through the soil, whether to allow excess water to sink away in the rains or to raise water from the subsoil during a drought. The smallness of the quantity of coarse sand on the other hand saves the soil from excessively rapid movements of water, so that the soil is not dried out to a great depth during a drought. Soils of this character are probably of the ideal physical composition for tea. They are very much in favour for fruit in Europe.

For want of a better term, soils of this character may be termed "silt loams."

Considerable areas of the following gardens give average analyses of "silt loam" types.

| | | |
|---|---|---|
| Birpara | ... | 4, 2, 3, 5, 1 |
| Demdima | ... | 2, 4, 3, 5, 1 |
| Dalgaon | ... | 3, 2, 4, 1, 5 |
| Dalmini | ... | 2, 3, 4, 5, 1 |
| Sarugaon | ... | 2, 3, 4, 5, 1 |

On the above gardens examples of the following soils also occur.

| | | | |
|---|---|---|---|
| Birpara | ... | 2, 1, 4, 3, 5 | 4, 1, 5, 2, 3 |
| Demdima | ... | 4, 3, 5, 2, 1 | |
| Dalgaon | ... | 3, 2, 1, 4, 5 | 2, 1, 3, 4, 5 |
| Dalmini | ... | 4, 3, 2, 5, 1 | |

At Ethelbarie the soils are generally of the much lighter type 2, 1, 4, 3, 5 but the "silt loam" type 3, 2, 4, 1, 5 also occurs.

The *Hantapara plateau* consists mainly of the two types 2, 4, 3, 5, 1 and 2, 1, 4, 3, 5 with the still lighter 1, 2, 4, 3, 5 type common at Ramjhora.

Lankapara and Gargunda are mainly of the 2, 4, 3, 5, 1 and 2, 1, 4, 3, 5 types.

The following heavier types also occur 4, 3, 2, 5, 1 and 4, 5, 2, 3, 1 also the very light type 1, 2, 3, 4, 5.

The heavier types are probably from Lankapara and the lighter types from Gargunda. The two gardens were sampled before separation.

At Dumchipara the four samples taken are all of the lighter 2, 1, 4, 3, 5 type, which changes into the closely related but still lighter type 1, 2, 4, 3, 5 at Ramjhora, where the 1, 4, 2, 3, 5 type is also found.

At Hantapara the bulk of the garden is of either the 2, 4, 3, 5, 1, or 2, 1, 4, 3, 5 type, the latter lighter type probably predominating. Patches of heavy grey silt of the 4, 5, 3, 2, 1 type also occur. These grey silts are obviously newer deposits overlying the normal soil of the garden, and are probably of the same origin as the infertile deposits already mentioned as occurring in the rest of the district. Those at Hantapara, however, have lost their excess of alkali, and accummulated a good store of organic matter. Although from their physical nature they are not so fertile as the rest of the garden, these heavy silts at Hantapara grow tea very successfully.

## SOILS OF THE DAINA TOORSA DISTRICT.

### Sandy types.

(Compare these with Mal Sands, to which type only Red Bank Tea Estate and Haldibari approximate closely).

| Tea Gardens. | Birpara. | Huldibari. | Ethelbari. | Bundapani. | Red Bank. |
|---|---|---|---|---|---|
| Soil type. | 2,1,4,3,5. | 1,4,3,2,5. | 2,1,4,3,5. | 3,2,1,5,4. | 1,2,3,4,5. |
| 1. Coarse sand .. | 20 | 36 | 27 | 13 | 45 |
| 2. Fine sand ... | 35 | 12 | 39 | 27 | 18 |
| 3. Silt ... ... | 13 | 14 | 8 | 42 | 14 |
| 4. Fine Silt ... | 19 | 21 | 18 | 6 | 10 |
| 5. Clay ... ... | 8 | 10 | 5 | 7 | 3 |
| Organic matter (Loss on ignition) ... | 3·5 | 7·5 | 2·5 | 4 | 9 |
| Soluble humus (Grandeau Organic matter) ... | 2·0 | 3·4 | 0·8 | 1·5 | 4·0 |
| Acidity ... ... | 1160 | 1780 | 625 | 950 | 1660 |

## Medium types.

| Tea Gardens. | Choona-bhutti. | Dem Dima. | Bunda-pani. | Banar-hat. | New Dooars. | Telepara. |
|---|---|---|---|---|---|---|
| Soil type. | 3,4,1,2,5. | 2,4,3,1,5. | 2,4,1,3,5. | 1,2,4,5,3. | 3,1,2,5,4. | 1,3,5,2,4. |
| 1. Coarse sand ... | 15 | 13 | 16 | 32 | 22 | 32 |
| 2. Fine sand ... | 14 | 26 | 32 | 18 | 22 | 13 |
| 3. Silt ... ... | 28 | 20 | 15 | 12 | 31 | 24 |
| 4. Fine silt ... ... | 24 | 23 | 21 | 17 | 3 | 8 |
| 5. Clay ... ... | 14 | 12 | 11 | 13 | 14 | 17 |
| Organic matter (Loss on ignition) ... ... | 4 | 6 | 4 | 5·5 | 7·5 | 4·5 |
| Soluble humus (Grandeau Org-matter) ... | 2·1 | 2·2 | 1·7 | 2·7 | 2·8 | 1·6 |
| Acidity ... ... | 2730 | 1980 | 1470 | 2260 | 1740 | 1470 |

## Heavy Types.

| Tea Gardens. | Binnaguri. | Gandrapara | Lakhipara. | Demdima. |
|---|---|---|---|---|
| Soil type. | 3,4,5,2,1. | 4,5,3,2,1. | 4,2,5,1,3. | 4,3,2,5,1. |
| 1. Coarse sand ... | 8 | 13 | 13 | 5 |
| 2. Fine sand ... | 9 | 7 | 23 | 19 |
| 3. Silt ... ... | 27 | 16 | 11 | 21 |
| 4. Fine silt ... ... | 26 | 34 | 24 | 31 |
| 5. Clay ... ... | 22 | 23 | 18 | 19 |
| Organic matter (Loss on igntion) ... ... | 7 | 8 | 9 | 4 |
| Soluble humus (Grandeau Org. matter) ... | ... | 3·9 | 3·4 | 1·3 |
| Acidity ... ... | ... | 1760 | 3650 | 1022 |

## Silt–Loam Types.

| Tea Gardens. | Birpara. | Chamurchi. | Dalgaon. | Dalmini. |
|---|---|---|---|---|
| Soil type. | 2,4,3,5,1. | 4,3,2,5,1. | 3,2,4,1,5. | 2,3,4,1,5. |
| 1. Coarse sand ... | 10 | 5 | 14 | 10 |
| 2. Fine sand ... | 35 | 17 | 20 | 38 |
| 3. Silt ... ... | 17 | 19 | 32 | 22 |
| 4. Fine silt ... ... | 22 | 39 | 19 | 17 |
| 5. Clay ... ... | 10 | 8 | 11 | 9 |
| Organic matter (Loss on ignition) ... ... | 4 | 9 | 3 | 3·5 |
| Soluble humus (Grandeau Org. matter) ... | 1·9 | 3·3 | 1·3 | 1·3 |
| Acidity ... | 1600 | 2730 | 2140 | 1510 |

## HANTAPARA PLATEAU SOILS.

| Tea Gardens. | Average lighter soils of the plateau. | | | | | | Heavy Soil. | |
|---|---|---|---|---|---|---|---|---|
| | Ramjhora. | Dumchipara. | Hantapara. | Gargunda. | Hantapara. | Lankapara. | A heavy clay from Lankapara. | The heavy new deposit at Hantapara. |
| Soil type. | 1,2,4,3,5. | 2,1,4,3,5. | 2,1,4,3,5. | 2,1,4,3,5. | 2,4,3,5,1. | 2,4,3,1,5. | 4,5,2,3,1. | 4,5,3,2,1. |
| 1. Coarse sand ... | 31 | 24 | 23 | 25 | 12 | 9 | 8 | 4 |
| 2. Fine sand ... | 26 | 27 | 25 | 30 | 24 | 36 | 17 | 7 |
| 3. Silt ... ... | 11 | 14 | 15 | 11 | 20 | 21 | 14 | 17 |
| 4. Fine silt ... | 23 | 17 | 18 | 13 | 23 | 22 | 28 | 44 |
| 4. Clay .... ... | 5·5 | 11 | 13 | 11 | 15 | 7 | 27 | 21 |
| Organic matter (Loss on ignition) ... ... | 3·5 | 6 | 5·5 | 4 | 6 | 4·5 | 6 | 6 |
| Soluble humus. (Grandeau organic matter) ... ... | 1·6 | 2·8 | 2·3 | ... | ... | ... | ... | 1·4 |
| Acidity. ... ... | 1060 | 2200 | 2340 | ... | ... | ... | ... | 1970 |

## INFERTILE ALKALINE SOILS OF DAINA TOORSA DISTRICT.

| Soil type. | Loss on ignition. | Grandeau organic matter. | Soluble in dilute acid. | Nitrogen. | Phosphoric Acid. | | Available potash. | Available lime. | Available magnesia. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Total. | Available. | | | |
| 2,3,4,5,1 ... ... | 4·04 | 0·84 | 8·0 | ·103 | ·145 | ·041 | ·009 | ·78 | ·11 |
| 2,1,3,4,5 ... ... | 3·0 | 0·68 | 5·4 | ·084 | ·112 | ·031 | ·012 | ·74 | ·14 |
| 4,3,2,1,5 ... ... | 5·5 | 0·65 | 0·63 | ·106 | ·116 | ·029 | ·007 | ·221 | ·016 |
| 4,3,2,5,1 ... ... | 5·1 | 0·55 | 0·21 | ·084 | ·126 | ·036 | ·005 | .16 | ·01 |
| 1,2,3,4,5* ... ... | 5·7 | 1·2* | 4·7 | ·118 | ·018 | ·018 | ·017 | ·98 | ·34 |
| 2,3,4,1,5 ... ... | 4·5 | 0·48 | 8·4 | ·05 | ·122 | ·012 | ·014 | ·76 | ·52 |
| 2,3,1,4,5 ... ... | 3·4 | ... | 8·5 | ... | ... | ... | ... | ... | ... |
| 4,2,5,3,1 ... ... | 4·5 | 0·49 | 1·3 | ·09 | ·125 | ·027 | ·016 | ·55 | ·17 |
| 4,2,3,5,1 ... ... | 3·2 | 0·46 | 0·6 | ·09 | ·104 | ·028 | ·014 | ·45 | ·12 |
| 3,2,4,5,1 ... ... | 2·8 | 0·02 | 5·9 | ·07 | ·20 | ·032 | ·014 | ·65 | 1·30 |
| 3,2,1,4,5 ... ... | 3·2 | 0·03 | 1·9 | ·14 | ·19 | ·032 | ·014 | ·60 | 0·34 |

* This soil, although alkaline, grows tea very fairly. Note "Grandeau" organic matter.

*The Toorsa-Jainti District.*—This is the district where the real grey sandy loam of the Dooars is seen over large areas. The prevailing whitish or light or dark grey colour of the soil generally is very noticeable. It is clearly a comparatively new deposit; frequently deep, overlying white silt or fine sand containing little plant food, occasionally overlying an older rich reddish brown surface soil at a depth within reach of the tea roots. The red-brown soil occasionally still appears as a surface soil. Generally the surface soil is rich but of no great depth; nevertheless the physical character of the soil is generally so good that tea does well, and the district includes some of the finest tea grown.

The characteristic soil types of the district are those referred to under the name "silt loam," when writing of Daina-Toorsa soils. They are soils mainly made up of the three medium fractions, fine sand, silt, and fine silt, and contain little of either coarse sand or clay. Such soils occur on every garden in the district and cover a large area on many of them. Mechanically they are splendid soils for tea Even now although mosquito blight is very distinctly wide-spread in the district, the above soils remain comparatively less attacked than the sands. When the quantity of fine silt is excessive, particularly when clay also is present in significant amount, soils of this nature may be too close-grained to rank as first class tea soils.

Sands (and sometimes very coarse sands) also occur, mainly in patches but sometimes over comparatively large areas. They are chemically very similar to the stiffer soils, but generally have a lesser depth of good surface soil. The sands are very distinctly inferior, as tea soils, to the "silt loams"; and on the sands mosquito blight generally appears first, and does more damage. The mechanical similarity of these sands to the "Mal Sands" is noticeable, but they have not generally the very high acidity and organic matter. The small patch from which the Dima sample was taken, however, bears a very close resemblance to the "Mal Sands."

Clay soils occur only on the gardens just under the hills, Toorsa and Rungamattie. These clay soils, in fact, are on the lowest slopes of the hills, and not on the plains proper.

Subsoils are generally lighter than surface soils, and gravel and stones very commonly appear below the subsoil. When either stones or sand form the lower subsoil splendid natural underdrainage is provided so that "blind" drains frequently appear to be sufficient. Where however the stones appear close to the surface, the growth of tea is not a commercial success, and where these "stony ridges" actually appear on the surface any attempt at planting is a matter of continual infilling, generally attended with disappointment. "Stony ridges," an occasional nuisance in the Daina-Toorsa district, here become a serious problem affecting large areas on many gardens.

No case of infertile alkaline soil has yet been found in this district. This is rather a matter for surprise since these soils are apparently very much what the alkaline deposits may be expected to weather into. Although the soils are of comparatively recent origin, it must be assumed that fresh deposition has now ceased.

The good stiff ( but not sticky ) types occur as below :

*Toorsa* ... Average 4, 2, 3, 5, 1 or 2, 4, 3, 5, 1 :
less common 4, 3, 5, 2, 1; 4, 5, 3, 2, 1;
3, 5, 4, 2, 1; 2, 4, 5, 3, 1.
Sandier types 3, 2, 1, 4, 5; 2, 4, 5, 3, 1;
1, 4, 1, 3, 5; also occur.

*Rungamattie* ... The 2, 4, 3, 1, 5 occurs. More commonly heavier types 4, 5, 1, 2, 3; 4, 1, 5, 2, 3; and a light type 2, 1, 4, 3, 5 is fairly common.

*Dalsingpara* ... Average 4, 3, 2, 5, 1; also 4, 2, 3, 5, 1;
2, 4, 3, 5, 1; 2, 3, 4, 5, 1.
Sandier types 2, 1, 4, 3, 5; 1, 2, 4, 3, 5.

*Hasimara* ... Average 4, 3, 2, 5, 1; also 4, 2, 3, 5, 1 and 2, 4, 3, 1, 5.
lighter types 4, 1, 2, 3, 5.
a heavier type 4, 3, 5, 2, 1 also occurs.

*Chuapara* ... 3, 2, 4, 5, 1 and 2, 4, 3, 5, 1.
No analyses of lighter soils available.

*Mechpara* ... Only one analysis available 4, 2, 3, 5, 1.

*Kalchini* ... 3, 4, 2, 5, 1 (only one analysis available, but this was taken as typical of garden).

A sandier soil (from Raimatang) is of 1, 4, 3, 5, 2 type.

*Dima* ... Average 4, 2, 3, 5, 1; also occurs 4, 3, 2, 5, 1, and one example from a very sandy patch is of 1, 2, 3, 4, 5 type which has the characteristics of the Mal Sands.

*Bhatkawa* ... 4, 2, 3, 5, 1 and 2, 3, 4, 5, 1.
also sandy type 1, 2, 4, 3, 5.

*Rajabhat* ... 2, 4, 3, 1, 5.

Here the sandy type 1, 2, 4, 3, 5 appears to be more common.

A sample taken from a sandy ridge is of the 1, 2, 3, 4, 5 type. It contains 95% sand and practically no clay. Naturally, on that spot tea cannot be established.

# CHARACTERISTIC SOILS OF THE TOORSA-JAINTA DISTRICT.

## Silt-loam types.

| Tea Gardens. | Bhatkawa. | Rajabhat. | Chuapara. | Kalchini. | Mechpara. | Hasimara. | Dima. | Dalsingpara. |
|---|---|---|---|---|---|---|---|---|
| Soil type. | 2,3,4,5,1. | 2,4,3,1,5. | 3,2,4,5,1. | 3,4,2,5,1. | 4,2,3,5,1. | 4,2,3,5,1. | 4,3,2,5,1. | 4,3,2,5,1. |
| 1. Coarse sand ... ... | 1·5 | 9 | 2 | 2 | 6 | 2 | 4 | 3 |
| 2. Fine sand ... ... | 43 | 39 | 29 | 21 | 25 | 21 | 22 | 11 |
| 3. Silt ... ... | 26 | 19 | 34 | 40 | 18 | 20 | 26 | 21 |
| 4. Fine silt ... ... | 19 | 23 | 26 | 24 | 34 | 40 | 30 | 53 |
| 5. Clay ... ... | 7 | 3·5 | 5 | 9 | 10 | 11 | 10 | 8 |
| Organic matter (Loss on ignition) | 3·5 | 5·5 | 4 | 4 | 7 | 5 | 5 | 4 |
| Soluble humus (Grandeau or Organic matter) ... ... | ... | ... | ... | ... | 3·3 | 2·2 | ... | 1·1 |
| Acidity ... ... ... | ... | ... | ... | ... | 1370 | 1850 | ... | 950 |

## CHARACTERISTIC SOILS OF THE TOORSA-JAINTA DISTRICT—*(Contd.)*

| Tea Gardens. | Sandy types. | | | | | | Heavy types. | |
|---|---|---|---|---|---|---|---|---|
| | Dima. | Bhatkawa. | Dalsingpara. | Rajabhat. | Hasimara. | Raimatang. | Rangamattie. | Toorsa. |
| Soil type. | 1,2,3,4,5. | 1,2,3,4,5. | 1,2,4,3,5. | 1,2,4,3,5. | 1,4,2,3,5. | 4,1,3,5,2. | 4,5,1,2,3. | 3,5,4,2,1. |
| 1. Coarse sand ... ... | 40 | 39 | 35 | 32 | 22 | 25·5 | 17 | 6 |
| 2. Fine sand ... ... | 31 | 18 | 31 | 28 | 21 | 12·5 | 16 | 16 |
| 3. Silt .. ... ... | 15 | 12 | 10 | 12 | 19 | 15 | 13 | 26 |
| 4. Fine Silt ... ... | 3·5 | 16 | 12 | 16 | 21·5 | 26 | 23 | 21 |
| 5. Clay ... ... | 3 | 9 | 7 | 7 | 11 | 13·5 | 21 | 24 |
| Organic matter (Loss on ignition) | 7·5 | 6 | 4·5 | 4 | 5·5 | 7 | 8·5 | 5·5 |
| Soluble humus (Grandeau or Organic matter) ... ... | 2·6 | ... | ... | 1·6 | ... | ... | ... | 2·4 |
| Acidity ... ... ... | 1630 | ... | ... | 1380 | ... | ... | ... | 2180 |

*The Jainti-Sankos District.*—This district falls naturally into two areas, comparatively light soils west of the Rydak and generally of a heavier nature east of that river. In both areas soils are chemically rich, and are generally characterised by high organic matter and nitrogen. The Jainti-Sankos soils appear to be older soils than those west of the Jainti; the white and grey colours are replaced by reddish browns. A few patches of dead black heavy soil also occur.

At Jainti in the north occur again patches of alkaline soil on which it has been found impossible to grow tea. In this case, as is usual on such infertile patches, the "Grandeau" organic matter is extremely low, while the matter soluble in dilute acid is high. In the case of these particular patches although the soil type varies considerably, fine silt is always the leading constituent (about 30%) and clay is always present in considerable quantity (about 17%) so that troubles are increased by the impervious nature of the soil, which is particularly marked in the absence of sufficient organic matter.

No analyses of the normal soils of this garden are available.

A little to the south-west at Phaskowa, the sandy type 2, 1, 3, 4, 5 predominates; although a heavy type is also found, the 1, 4, 5, 2, 3.

At Kartik the soils are generally sandy, types so light as the 1, 2, 3, 4, 5 being found, but the 2, 1, 4, 3, 5 is probably more common.

At Dhowlajhora the type 2, 3, 4, 5, 1 predominates. In this type of soil as found at Dhowlajhora the coarse sand and clay each average only 2 or 3 per cent. Although below the average of the district in nitrogen, such soils are physically very well suited for tea.

The sandy type 2, 1, 4, 3, 5 also occurs.

East of the Rydak the soils generally are, or have been, exceptionally rich. They appear very generally to have lain under wet conditions, accumulating fertility, for some time before opening out. A few soils which have been very long under cultiva-

tion now show a comparative deficiency in organic matter which accounts for their lesser fertility, but on the whole the soils are still in splendid condition.

At Rydak the type 2, 4, 1, 3, 5 appears to predominate, but the physical nature of the soil varies greatly from place to place. The uncommon silt types 2, 3, 5, 1, 4 and 3, 2, 5, 1, 4 (previously noted at Rheabari) also occur. Rydak generally is exceptionally rich in "Grandeau" organic matter (soluble humus), and appears to have lain a long time under water-saturated conditions before opening out and draining. The 2, 3, 5 and 3, 2, 5 types are particularly rich in this respect, the "Grandeau" organic matter being between 4 and 5 per cent. in all four samples analysed. Medium sand types such as 2, 1, 4, 3, 5 also occur.

At Newlands the related types 3, 4, 5, 2, 1 and 4, 3, 5, 2, 1 are common. When these types contain a clay fraction of about 20%, they become difficult soils to work unless the organic matter content is very high, as it often is when the soils are newly opened out. Sandier types 2, 3, 4, 5, 1; 2, 1, 4, 3, 5; and 2, 1, 3, 4, 5 also occur.

At Kumargram similar heavy types 4, 5, 3, 2, 1 and related types are found, but the very fine medium types 2, 3, 4, 5, 1 and 2, 4, 3, 5, 1 and a light type 2, 1, 4, 3, 5 occupy large areas.

At Sankos the soils are very similar to those found at Kumargram.

The soils between the Rydak and the Sankos have a general resemblance to those of the Hantapara plateau.

## SOILS OF JAINTI-SANKOS DISTRICT.

| | Infertile patch from Jainti. | Phaskowa. | Kartik. | Dhowla-jhora. | Rydak. | | Newlands. | | Kumargram. | | Sankos. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil type. | 4,3,5,2,1. | 2,1,3,4,5. | 1,2,3,4,5. | 2,3,4,5,1. | 2,4,1,3,5. | 4,3,5,1,4. | 4,3,5,2,1. | 2,1,3,4,5. | 4,5,3,2,1. | 2,4,3,5,1. | 2,1,4,3,5. |
| 1. Coarse sand ... ... | 4 | 36 | 78 | 1 | 18 | 10 | 2 | 19 | 2 | 9 | 24 |
| 2. Fine sand ... ... | 6 | 40 | 14 | 43 | 33 | 26 | 12 | 47 | 4 | 40 | 29 |
| 3. Silt ... ... | 24 | 10 | 5 | 28 | 14 | 34 | 25 | 15 | 21 | 14 | 13 |
| 4. Fine Silt ... ... | 43 | 8 | 0·5 | 19 | 25 | 15 | 30 | 9 | 35 | 18 | 16 |
| 5. Clay ... ... | 16 | 4 | 1 | 2 | 5 | 13 | 21 | 6 | 28 | 12 | 12 |
| Organic matter (Loss on ignition) ... ... | 6·5 | 2·5 | 2 | 6 | 5 | 11 | 10 | 3·5 | 9 | 6·5 | 5 |
| Soluble humus Grandeau (Organic matter) ... ... | 0·3 | 0·9 | 0·8 | 1·4 | 2 6 | 5·1 | 2·1 | 1·0 | 1·7 | 3·2 | 2·3 |
| Acidity ... ... | Alkaline | 900 | 650 | 1810 | 2510 | 2240 | 3120 | 2030 | 2230 | 2530 | 2770 |

# OBSERVATIONS CONCERNING TANNIN IN THE TEA LEAF.

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AND

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## Introduction.

In a previous number of this Journal it was shown that the price of Assam teas is based largely on the tannin content of the tea (2). Prices above the average are paid chiefly for flavour, aroma and in some cases for exceptional pungency. North-East Indian teas are generally pungent teas with "body" and the comparatively low prices paid for these qualities is more than counterbalanced by the large crops given in North-East India. The qualities of pungency, "briskness," "body" and thick liquors are all connected more or less closely with tannin products. The "cream" which separates from tea infusion on cooling is also due in part to tannin products.

Finished Indian Teas contain considerably more tannin than Ceylon and China teas as is shown by the table below (1).

| | Tannin % | | | |
|---|---|---|---|---|
| | Variation. | | | Average. |
| Indian Teas ... ... | 13·32 | to | 14·98 | 14·33 |
| Ceylon „ ... ... | 10·31 | to | 13·91 | 12·29 |
| China „ ... ... | 7·27 | to | 10·94 | 9·50 |

These percentages are calculated on dry finished black teas and are not comparable with tannin values shown later on. When the

shoot is first plucked it contains from 25 to 30% tannin which, chiefly during the fermentation process in manufacture, is reduced to about 15%. The tannin which disappears goes to make cup colour and "body."

The excess of tannin has been used as an argument against Indian teas in favour of China and Ceylon teas. However, China bushes grown in Assam have about the same tannin content as Burma and Assam bushes. Thus shoots consisting of two leaves and a bud plucked in July showed the following tannin percentages :—

| Plucking date. | Tannin% on dry leaf. | | |
|---|---|---|---|
| | Burma. | Assam. | China. |
| July 17th ... ... | 25·92% | 24·20% | 24·53% |
| July 31st ... ... | 26·57% | 24·75% | 24·77% |

Some years ago an article was published in the *Lancet* showing that the harmful effect of tea tannin was removed when that body was combined with caffeine. It was also shown that in the better quality Indian teas most of the tannin was thus combined. This point has not been further studied but whether most of the tannin is combined with caffeine or not, the compound, caffeine tannate, would be decomposed into its components by the acids of the stomach.

It is highly probable that the percentage of caffeine tannate is influenced by the manufacture of the tea, for the proportion of tannin combined with caffeine is different in fresh leaf and finished tea. Thus in green leaf the ratio of combined tannin to caffeine is about 4 to 1 whilst after manufacture it falls to about 3 to 1 and sometimes less.

Considering that tannin is such an important factor, perhaps the controlling factor, in determining the quality of the teas of North-East India, any study connected with the quality of such teas must necessarily start with the tea tannin.

**Fig. I.**

Curve showing crop given each four weeks by ¼ acre Singlo Tea Plots at Tocklai. Season 1921.

Total crop—pruned 14" 489 lbs. green leaf.

" " — " 10" 433 " " "

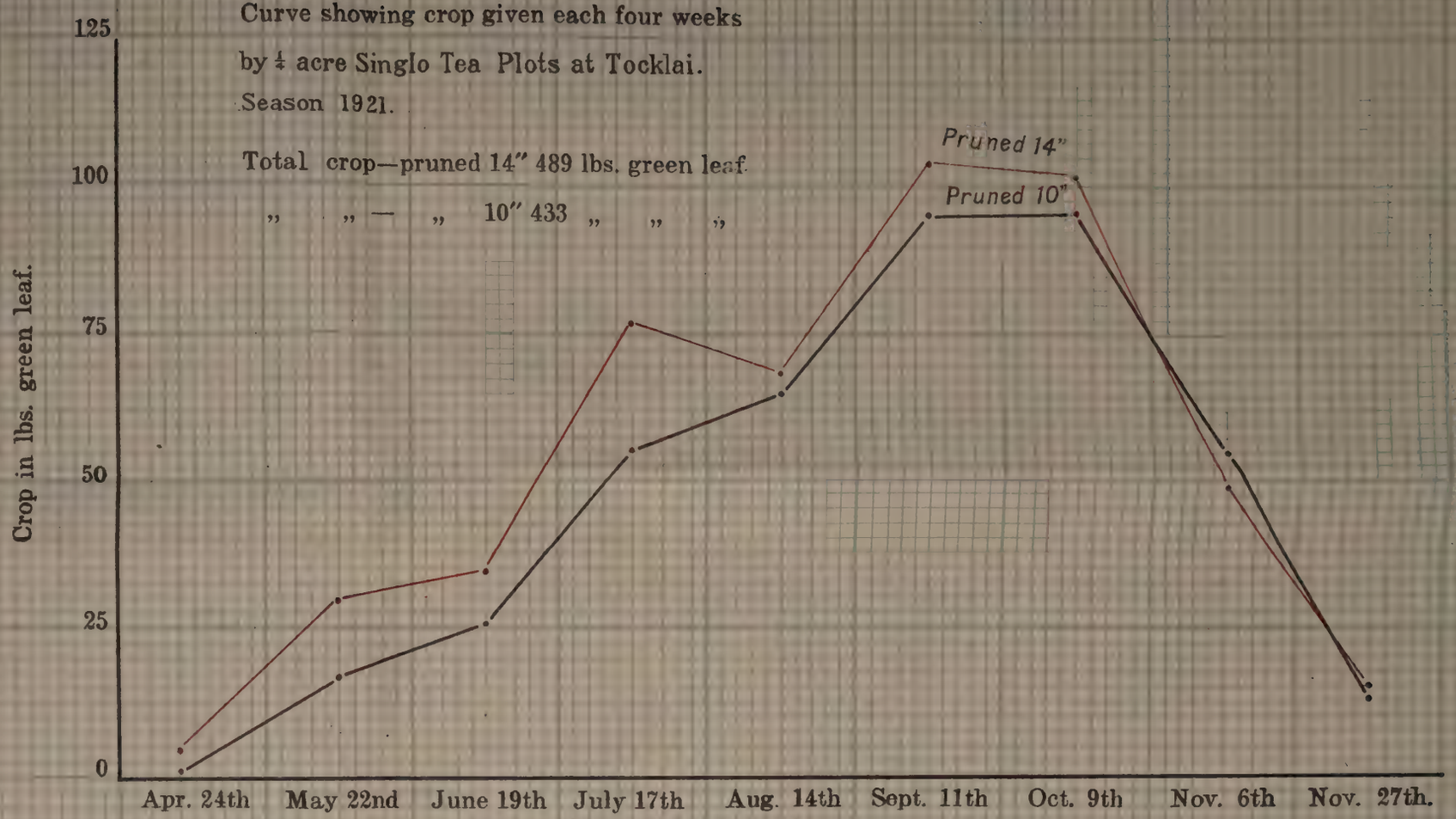
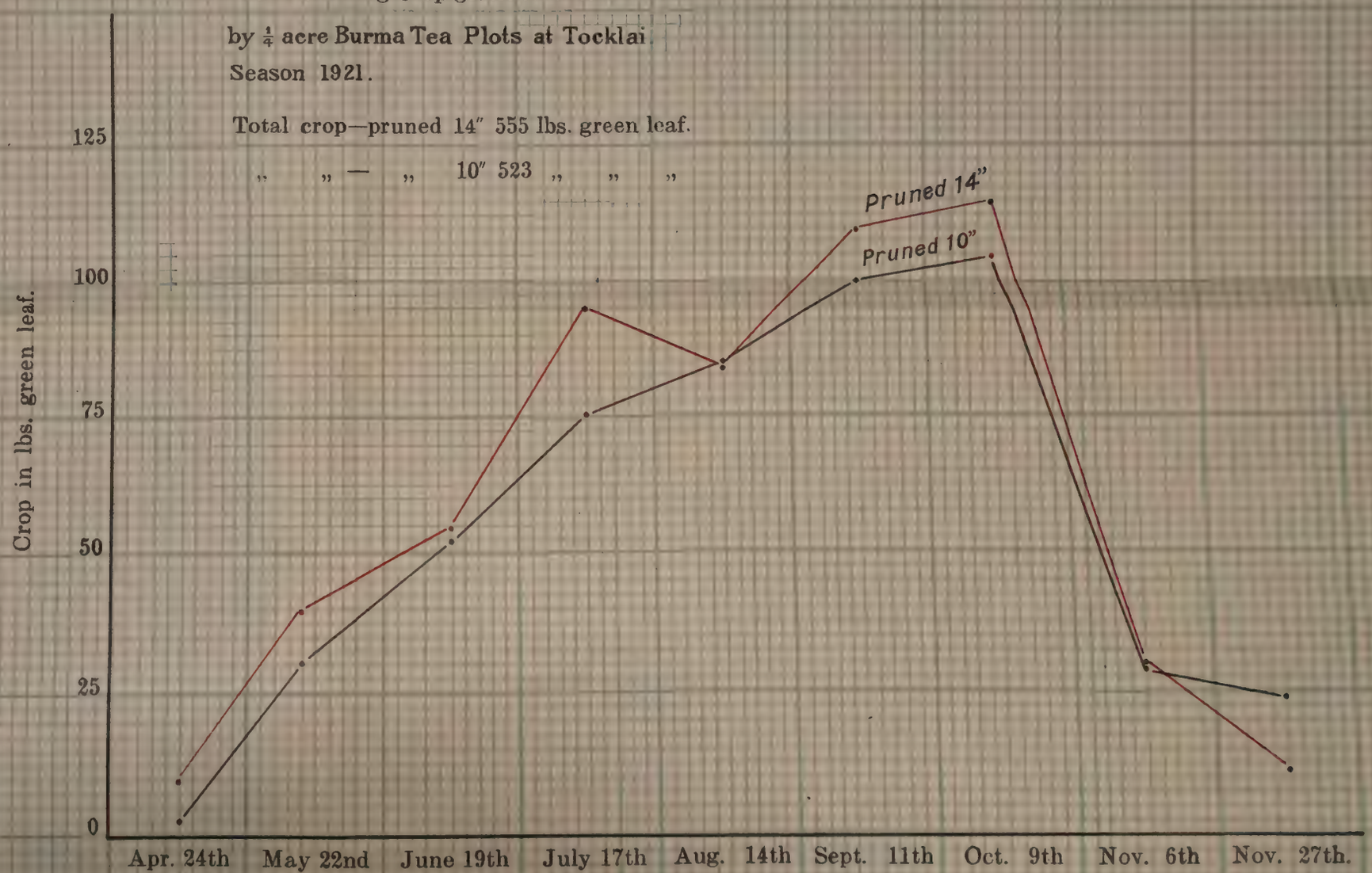



**Fig. II.**

Curve showing Crop given each four weeks by ¼ acre Burma Tea Plots at Tocklai. Season 1921.

Total crop—pruned 14" 555 lbs. green leaf.

" " — " 10" 523 " " "



Below is given some account of preliminary work in this connection.

## Experimental Details.

In the experiments described, the tannin was estimated by Lowenthal's method (5). Briefly, this method consists in estimating the matter in solution which is oxidisable by permanganate before and after precipitation by gelatine. The difference is a measure of the tannin bodies. In order to convert this difference into actual weight of tannin, a factor which naturally varies with different tannins, must be used.

A factor was worked out for tea tannin so that the Lowenthal method gave similar results to the tannin as determined gravimetrically by the hide powder method. The factor was found to be 0·0416 grams tea tannin for each c. c. normal permanganate.

In order to study the variation in the tannin content of tea leaf throughout the plucking season the crop from two-half acre blocks of tea from the Tocklai Clearance was used. One block consisted of dark leaved Burma bushes and the other of light leaved Singlo, Assam indigenous, bushes. On each block there were two types of pruning, one half the block being pruned annually and the other half biennially. In the year under consideration (1921) both blocks had been pruned, the annual to 14″ and the biennial to 10″. Both were plucked at 27″, and plucked to the "jhanum" from the commencement of the plucking season.

As soon as the shoots were plucked they were divided into four parts, *viz*:—the bud, the first and second leaf, and the stalk between the first and second leaf. Each portion was boiled for half an hour with water and the filtered liquid was analysed for tannin.

The crop curves for both plots showing the separate yields from the 14″ and 10″ pruned bushes are given in Figures I and II. The total crop for each four weeks is given. The season ended on Nov. 27th so the last point on the curve represents a 3-week crop. By this method of reckoning, the general trend of the crop is shown. The slackening in the upward trend of the crop shown in August is part of the depression extending over four weeks at

this period, details of which are given in an earlier number of this Journal (3).

Apart from the fact that the Burma bushes give a larger crop than the Singlo it is notable that the crop is given earlier. Thus the half season with the Burma 14″ and 10″ pruned bushes comes on August 18th and 25th respectively whilst the half season for the Singlo bushes is August 25th and September 1st respectively.

It is interesting to notice that the crop given by the Singlo bushes for the four weeks ending Nov. 6th is almost double that given by the Burma bushes. The light leaved Singlo bushes were flushing much more vigorously at the end of the season than the dark leaved Burma bushes.

## Variation in Tannin with Season.

Below are shown the results of the study of the variation in the tannin content of tea leaves. The curves on Figs. III and IV also show the variation.

*Tables showing the variation in Tannin content of Tea Shoots during the Season 1921.*

*Tannin content is shown as percentage on dry leaf.*

### Table I.

*Burma Tea pruned to 14″, plucked at 27″*

| Plucking date. | Bud. | No. 1. Leaf. | No. 2. Leaf. | Stalk. |
|---|---|---|---|---|
| May 26th ... ... | 19·88% | 18·02% | 13·70% | 6·28% |
| June 9th ... ... | 19·46% | 23·90% | 19·93% | 10·13% |
| „ 23rd ... ... | 21·52% | 22·21% | 18·44% | 11·47% |
| Aug. 4th ... ... | 19·92% | 21·00% | 18·98% | 11·16% |
| „ 18th ... ... | 25·67% | 26·84% | 23·74% | 10·39% |
| Sept. 1st ... .. | 31·20% | 31·93% | 25·31% | 8·67% |
| „ 17th ... ... | 32·10% | 31·57% | 25·62% | 13·51% |
| „ 29th ... ... | 28·68% | 28·52% | 24·07% | 14·73% |
| Oct. 20th ... ... | 23·89% | 25·65% | 21·78% | 11·87% |
| Nov. 3rd ... ... | 29·13% | 27·74% | 24·72% | 15·54% |
| „ 17th .. ... | 28·89% | 28·65% | 21·63% | 15·73% |
| Average ... | 25·49% | 26·37% | 21·63% | 12·37% |

Fig. III.

# GRAPHS SHOWING VARIATION IN TANNIN CONTENT OF GREEN LEAF THROUGHOUT THE SEASON 1921.

RED LINE DENOTES TEA CUT TO 10"
BLACK „ „ „ „ „ 14"
BOTH CLOSE PLUCKED TO 27"

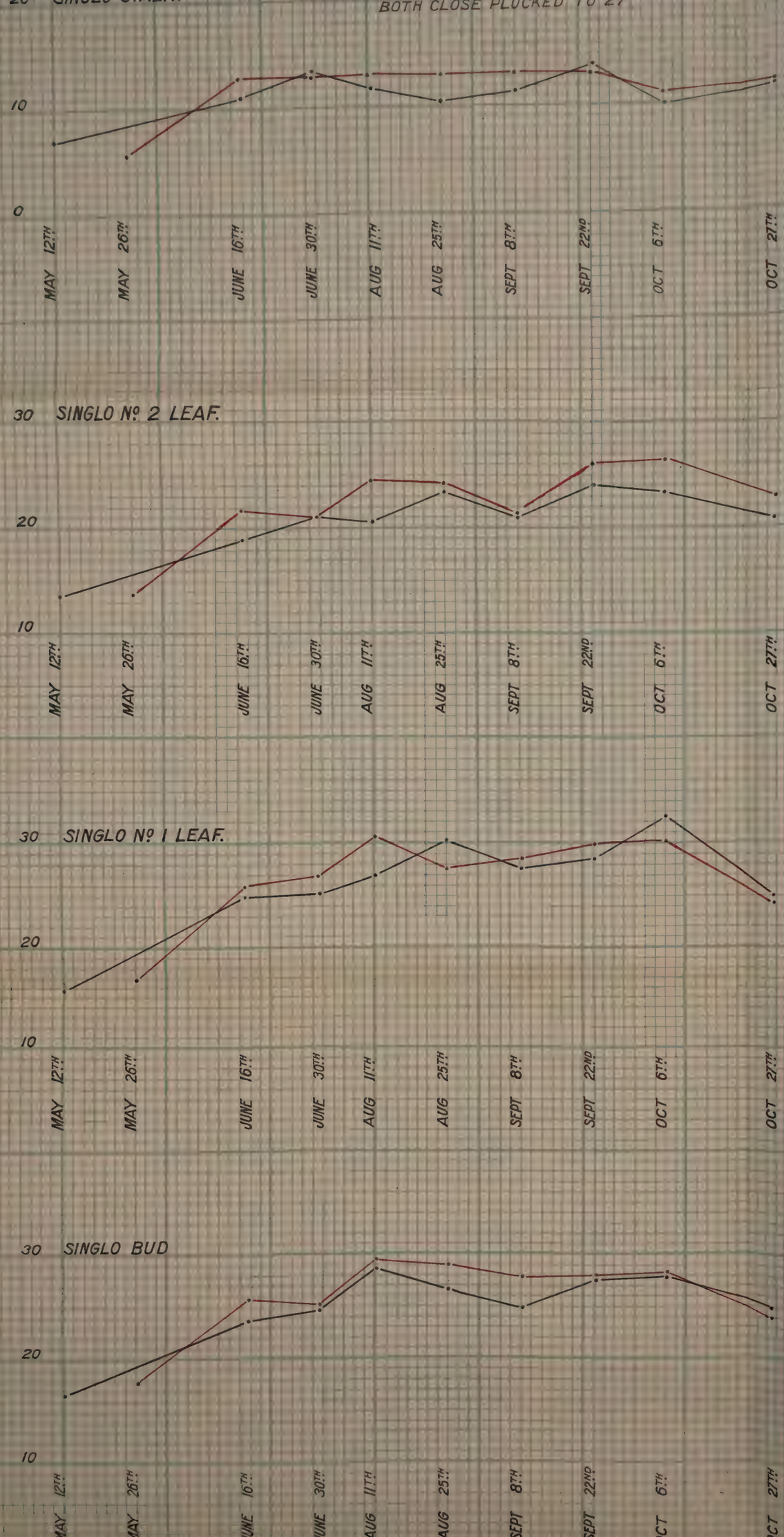
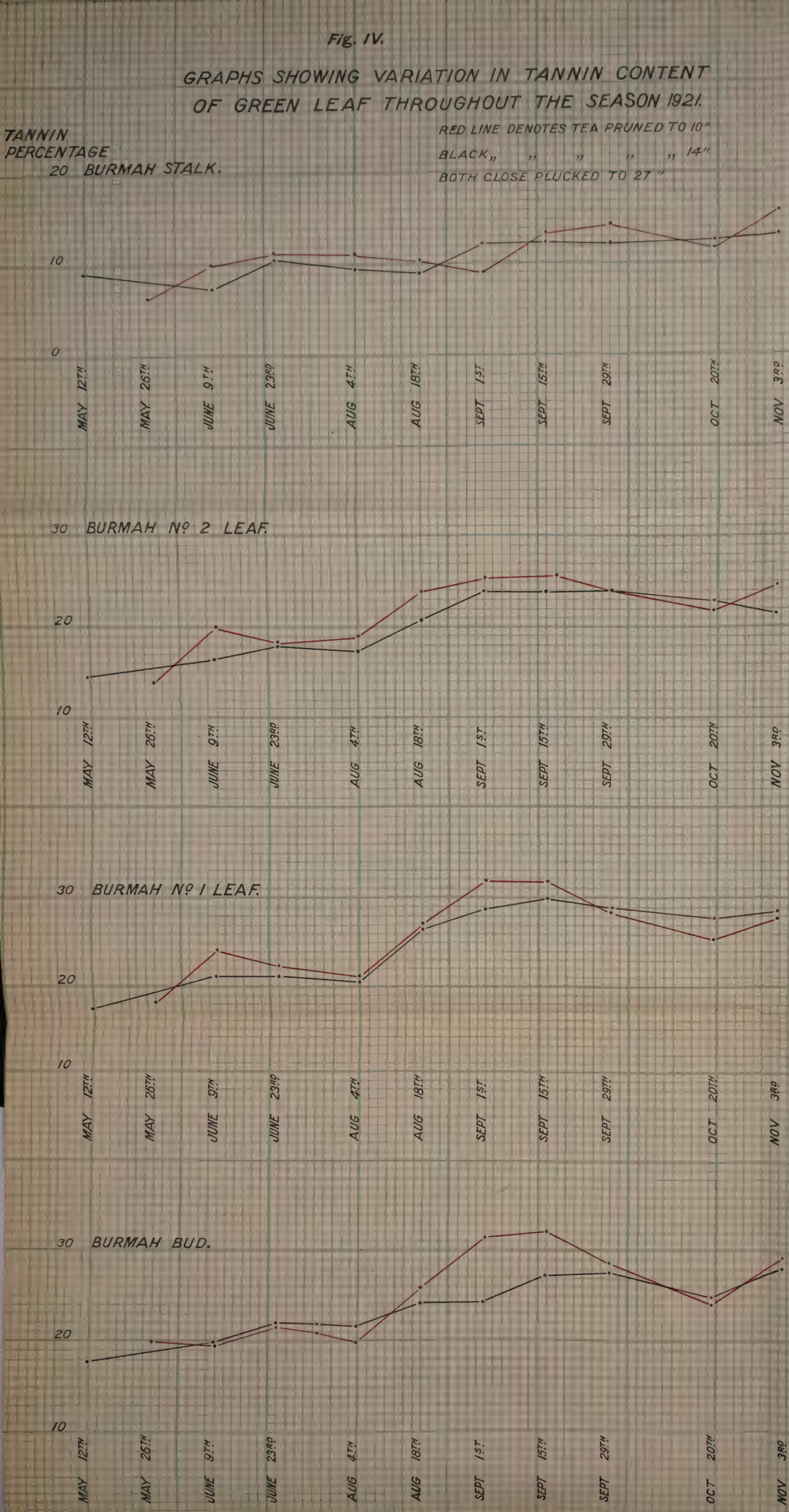


Fig. IV.

# GRAPHS SHOWING VARIATION IN TANNIN CONTENT OF GREEN LEAF THROUGHOUT THE SEASON 1921.

RED LINE DENOTES TEA PRUNED TO 10"
BLACK " " " " 14"
BOTH CLOSE PLUCKED TO 27"

TANNIN PERCENTAGE



## Table II.

*Burma Tea pruned to 10", plucked at 27"*

| Plucking date. | Bud. | No. 1 Leaf. | No. 2 Leaf. | Stalk. |
|---|---|---|---|---|
| June 9th ... ... | 19·72% | 21·00% | 16·28% | 7·76% |
| „ 23rd ... ... | 21·90% | 20·93% | 17·99% | 10 53% |
| Aug. 4th ... ... | 21·20% | 21·40% | 17·26% | 9·62% |
| „ 18th ... ... | 24·05% | 26·39% | 20·54% | 9·04% |
| Sept. 1st ... ... | 24 10% | 28·57% | 23·97% | 12·31% |
| „ 17th ... ... | 27·10% | 29·90% | 23·67% | 12·48% |
| „ 29th ... ... | 27·51% | 28·91% | 24·15% | 12·32% |
| Oct 20th ... | 24·96% | 27·88% | 22·86% | 12·40% |
| Nov. 3rd ... ... | 27·48% | 28·56% | 21·38% | 13·17% |
| „ 17th ... ... | 28·33% | 30·28% | 22·80% | 16·54% |
| Average ... | 24·67% | 26·28% | 21·09% | 11·62% |

## Table III.

*Singlo Tea pruned to 14", plucked at 27".*

| Plucking date. | Bud. | No. 1 Leaf. | No. 2 Leaf. | Stalk. |
|---|---|---|---|---|
| May 26th ... ... | 17·50% | 16·50% | 13·45% | 5·50% |
| June 16th ... ... | 25·68% | 25·66% | 21·94% | 12·72% |
| „ 30th ... ... | 24·82% | 26·68% | 20·91% | 12·61% |
| Aug. 11th ... ... | 29·36% | 30·15% | 24·54% | 12 92% |
| „ 25th ... ... | 28·94% | 27·33% | 24·09% | 12·88% |
| Sept. 8th ... ... | 27·50% | 28·04% | 21·04% | 12·66% |
| „ 22nd ... ... | 27·61% | 29·46% | 25·92% | 12·68% |
| Oct. 6th ... ... | 28·12% | 30·00% | 26·32% | 11·09% |
| „ 27th ... ... | 23·67% | 24·02% | 22·78% | 11·89% |
| Nov. 10th ... ... | 27·36% | 26·36% | 22·08% | 12·72% |
| „ 24th ... | 23·93% | 26·17% | 21·00% | 11·94% |
| Average ... | 25·85% | 20·40% | 22·19% | 11·78% |

TABLE IV.

*Singlo Tea pruned to* 10″, *plucked at* 27″.

| Plucking date. | Bud. | No. 1 Leaf. | No. 2 Leaf. | Stalk. |
|---|---|---|---|---|
| May 12th ... ... | 16·40% | 15·49% | 13·48% | 7·02% |
| June 16th ... ... | 23·47% | 24·69% | 18·74% | 10·98% |
| ,, 30th ... ... | 24·48% | 24·75% | 20·86% | 13·34% |
| Aug. 11th ... | 28·45% | 26·69% | 20·37% | 11·32% |
| ,, 25th ... ... | 26·12% | 30·04% | 23·24% | 10 18% |
| Sept. 8th ... | 24·92% | 27·20% | 20·70% | 11·31% |
| ,, 22nd ... ... | 27·31% | 28·05% | 23 72% | 13·50% |
| Oct. 6th ... ... | 27·67% | 32·14% | 23·14% | 9·71% |
| ,, 27th ... ... | 24·49% | 24·68% | 20·35% | 11·47% |
| Nov. 10th ... ... | 28·40% | 26·83% | 22·73% | 13·47% |
| ,, 24th ... ... | 25·08% | 25·02% | 19·32% | 12·02% |
| Average ... | 25·16% | 25·96% | 20·65% | 11·32% |

Some of the points to be noticed are :—

(*a*) The lighter pruned bushes give more tannin than the lower pruned bushes.

This is of interest in that low pruned tea gives poorer quality tea than high pruned. It must be remembered however that the high pruned bushes were plucked on 13″ of new wood whilst the low pruned were plucked on 17″ of new wood. Had the low pruned bushes been plucked to 23″ the tannin content might have been nearer that of the other bushes.

On the other hand, the quicker rate of growth of the low-pruned bushes might in any case lower the tannin content. It is of interest to note (4) that with fruit trees the slower the growth of the tree the more concentrated the cell sap. Thus, when a tree is lightly pruned, the cell sap is more concentrated. This same argument may apply to the tea bush.

(*b*) The bud and the first leaf constitute the part of the shoot richest in tannin, but the first leaf is distinctly richer than the bud.

Plucking immature leaf may therefore lower the tannin percentage of the fine grades of tea manufactured.

The depressing effect of coarse plucking on quality will be appreciated from the table below showing the average percentage

composition of a fine plucked shoot. The second leaf and stalk, both poor in tannin, comprise well over 60% of the shoot.

| | | |
|---|---|---|
| Bud | ... ... | 14% of shoot plucked. |
| First leaf | ... ... | 21% „ „ |
| Second leaf | ... ... | 38% „ „ |
| Stalk | ... ... | 27% „ „ |
| | | 100% |

As more leaves of the shoot are taken, the tannin content still further decreases until the influence of the bud and first leaf is quite overshadowed by the depressing effect of the coarser leaves. Below are given figures which illustrate this.

| | Moisture % | Tannin% (on dry leaf) |
|---|---|---|
| Bud ... ... ... | 76·60 | 27·94 % |
| First leaf ... ... ... | 78·60 | 27·94 % |
| Second leaf ... ... ... | 76·80 | 21·34 % |
| Third leaf ... ... ... | 76·90 | 17·84 % |
| Fourth leaf ... ... ... | 74·80 | 14·50 % |
| Upper stalk ... ... ... (Bud to second leaf) | 86·90 | 11·70 % |
| Lower stalk ... ... ... (2nd to 4th leaf) | 84·60 | 6·43 % |

These decreases in tannin with the age of the leaf have been noticed with other plants, *e.g.*, the horse chestnut.

(*c*) The Singlo leaves are, considering individual pluckings, usually richer in tannin than the Burma leaves. This follows the generally accepted idea that light-leaved bushes give better teas than dark-leaved bushes.

The average tannin content of the Burma leaves in Table II is higher than that of the Singlo leaves in Table IV. This is because the Singlo pluckings include one made on May 12th when all the tannin values were low whereas the first analyses on Burma 10″ pruned tea were made on June 9th, after the rise in tannin values which occurs at the beginning of the season.

For the year in which these experiments were made it is noticeable that the tannin content of the Singlo leaves is steady throughout the season whereas for the first part of the season the tannin of the Burma leaves is distinctly low.

(*d*) Seasonal variation.

The low value given by the May shoots is remarkable. The crop in this month is made up partly of the "tipping" which consists, to a certain extent, of slowly grown shoots. The May flush is chiefly made up of shoots which grow quickly as soon as the atmospheric moisture increases as is usual during this month.

In October there is a temporary falling off in tannin. It is impossible at present to explain this. The growing conditions at this period suddenly change, as reference to the Meteorological Chart for 1921 will show (3). Thus the atmosphere has dried suddenly before the temperature has appreciably fallen. In November, although the absolute humidity continues to fall the relative humidity is increasing by virtue of the fall in temperature, and growing conditions are thus again altered.

Only a few such sudden changes in the tannin content of the tea leaf have so far been observed. Thus at the end of June 1922 after the tannin content of the total shoot had risen steadily during the preceding two months from 20% to 30%, there came a sudden drop to 25%. There were no obvious weather changes to account for this, but the rate of growth of the leaf suddenly diminished and the shoots were all about half their usual weight.

The general increase in tannin as the season advances corresponds with the change noticed with regard to other plants rich in tannin, especially the oak and some of the conifers.

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# A COMPARISON OF THE VALUES OF FLOUR PHOSPHATES WITH THOSE OF BONE MEAL

BY

H. H. WILES, M.A.

In Part I of this Journal for 1921 a note was published on the constitution of a sample of Flour Phosphate received by the Department, and the results of a trial of its availability, as compared with that of Bonemeal, upon a six-week crop of cowpeas at Borbhetta.

On analysis the sample proved to be a Calcium Phosphate, giving the following average figures :—

| | |
|---|---|
| Iron and Alumina ... ... | 12% |
| Lime ... ... ... | 56% |
| Magnesia ... ... ... | trace |
| Total Phosphoric acid ... ... | 26% |
| Phosphoric acid, citric acid soluble ... | 6% |

This crop was grown in the cold-weather (October-November 1920) and received no rain at all with the result that it practically failed, the plants on all the plots making but very little growth and also being attacked by a root disease.

Water-supply being at that season a factor of primary importance, the effects of small dressing of phosphate were naturally only slight, and the results of this first trial may therefore be regarded as almost negligible.

The trial was therefore repeated in the early rains of 1921, after a lapse of six months, but the crop which was sown in the third week in April had to be left in the soil for ten weeks, instead of six, before it could be gathered, owing to the weather throughout May being unfavourable to green crops.

Even then, the crops on the check-plots were barely ready when pulled up, although those on the manured plots, particularly the ones which received the Flour Phosphate, had yellowed somewhat and were obviously over-mature.

| Six plots receiving :— | Average crop in lbs. per acre. | | Percentage of Check-plot. | |
|---|---|---|---|---|
| | 1920. | 1921. | 1920. | 1921. |
| No manure (Check) ... ... ... | 694·4 | 1814·4 | ..... | ..... |
| Flour Phosphate 40 lbs. $P_2O_5$ per acre ... | 806·4 | 3852·8 | +16 | +113 |
| Bone meal " " " " ... | 851·2 | 5353·6 | +24 | +195 |
| Unmanured strips (3 ft. wide) at sides of each plot ... ... ... ... | ..... | 1568·0 | ..... | −13 |

These figures render it obvious that phosphate is here a controlling factor in growth, as both manures show a very distinct effect in spite of the all-round poorness of the crops, due largely to the unfavourable weather conditions already mentioned and also, on the manured plots only, to pre-maturity.

It is noticeable that the Bonemeal in each case gives somewhat the better crop, the Flour Phosphate comparing slightly less favourably with it in 1921 than in the first trial, the ratio of the crop increases produced by the two manures respectively being only 5 to 3 in 1921 instead of 3 to 2 as in 1920.

It is very interesting to note that the effects of the manures are relatively the same on crops grown in the dry and wet weather.

The distinct decrease in fertility, shown by the unmanured drainside strips in comparison with the check-plots, is also of interest, as it is evidently due to "edge effect."

As already recorded for the 1920 sowing, the plots sown with brown imported seed again gave decidedly better crops than those sown with white local seed, although the two varieties were reversed on the plots at the second sowing. This superiority of the brown seed was particularly noticeable where the Flour Phosphate had been applied, the plots sown with it showing an increase of 64% over the white.

*Residual Values :* In order to test the residual effects of the manures applied in 1920, a further crop of white cowpeas was sown on these plots on May 24th of this year (1922).

Weather was on the whole favourable and the plants made very fair growth on the manured plots, one of the Flour Phosphate plots being quite exceptionally good and giving 60% more crop than the next best plot.

The crops were scarcely mature, however, when they were pulled up and weighed on July 7th, although patches of yellowing plants were very noticeable here and there on the manured plots. The plants on the check-plots would undoubtedly have increased in size if left a little longer in the soil.

In the following table the yields obtained are compared with those of the two previous sowings :—

| Manures applied. | Lines of Plants per plot. | Average yields for 6 plots in lbs. per acre. | | | | Percentage Increase or Decrease compared with Check-Plots. | | |
|---|---|---|---|---|---|---|---|---|
| | | 1920. | 1921. | 1922 (Residual). | Total (3 yrs.) | 1920. | 1921. | 1922 (Residual). |
| Flour Phosphate | 5 | 806·4 | 3852·8 | 3158·4 | 7817·6 | +16 | +113 | +28 |
| Bonemeal ... | 5 | 851·2 | 5353·6 | 2643·2 | 8848·0 | +24 | +195 | +7 |
| Nil (Check-plot) | 5 | 694·4 | 1814·4 | 2464·0 | 4972·8 | ... | ... | ... |
| Nil (Drainside half-plots) ... | 4 | ..... | 1568·0 | 1769·6 | ..... | ... | −13 | −28 |

It will be observed that, in spite of the distinctly greater initial effect of the Bonemeal up to six months after application, the contrary applies in cases of the residual effects after 18 months, Flour Phosphate having now produced an increase over the checks four times as big as that given by Bonemeal.

At the same time Bonemeal is still quite definitely in front on the total crops for the three years, and it is doubtful whether the residual superiority of the Flour Phosphate is really either as large or as significant as the figures would appear to indicate, as all the manured plots, with the exception of the one Flour Phosphate plot already referred to, gave only slight increases over the check-plots.

The "edge effect" is slightly more marked on the unmanured drainside strips than last year, owing probably to the removal of the two previous crops having to some extent decreased their fertility.

*Conclusions:* It would therefore appear that Bonemeal contains the higher percentage of rapidly available phosphates, in spite of its less finely divided state.

This may be due to the higher percentage of insoluble phosphates of iron and aluminium in this instance 12%, present in the Flour Phosphate.

The latter, however, seems to be more lasting in its effects, while its physical state makes it easier to apply evenly, and renders more completely and rapidly available such proportion of its phosphate content as may be used by the crop at any time, as is evidenced by the fact that the Flour Phosphate plots were in all cases the first to mature.

# A NOTE ON CRICKETS

BY

E. A. ANDREWS, B.A.

An account of the life-history of the cricket might very well commence at the present time of year (October), for the ceaseless chirruping which is going on just now indicates the fact that the breeding season is in full swing. It also indicates the fact that this is not the best time for the application of poison baits. More will be said of this later.

This chirruping "song" is produced by the male, who sits at the mouth of his burrow with his head towards the entrance, and is presumed to attract the female. Be that as it may, during the day-time they may now be found in couples, male and female, in the burrows.

Occupied burrows may be recognised by the presence of freshly turned up earth around the burrow. This, however, is not invariably present now, but occupied burrows are closed in the day-time by an earthen plug a short way inside, and the presence of this plug is a sure sign of occupation. The female lays her eggs at the bottom of the burrow, embedding them in the soil with an apparatus called the ovipositor, specially adapted for that purpose. They are thus thoroughly well protected.

The eggs are being laid in September and October, and hatch in October and November. After hatching the young crickets live in the parent burrow for two or three days. They then disperse, and each makes a separate burrow for itself, coming out at night to feed. The burrows are short, only 3 to 6 inches down, and may be readily recognised by the small heaps of fresh earth, each with a depression in the centre indicating the mouth of the hole, thrown up on the surface. At this stage the insect makes a fresh burrow each night.

As the insects grow the burrows become longer and cease to be straight, and they may have ramifications. As they grow, also, they are able to tackle larger and larger plants, and thus it comes about that serious damage to nurseries begins to occur about March or April. By July the insects are becoming adult and in this stage they appear to remain in the same hole, or they may occupy empty holes. At any rate they seem not to make new holes for themselves.

The adult does little damage to tea as compared with the younger forms, partly because it has passed the period of growth and is not so voracious, partly because the plants have grown too high, and become too strong to be tackled.

It would be well to begin control measures now by pouring kerosene emulsion, 1 part stock solution to 20 parts water (*see* "Notes on the Spraying of Tea," Indian Tea Association Pamphlet No. 1, 1915, for mode of preparation of kerosene emulsion) into the holes to kill any adult which may not yet have lain eggs. It is hardly feasible to destroy the eggs at the bottom of the burrow, though it might be thought that some solution might be poured in to kill them. This is unfortunately not possible. In order to ensure contact with the eggs the burrow would have to be filled, and since in the majority of cases the burrow turns upwards at the end the eggs are still further protected. Any liquids which kill eggs are exceedingly corrosive, and large quantities of such fluids cannot be poured into soils with impurity, and when the chance of the fluid achieving its object is so small it is certainly not worth while.

The poison bait might come in handy if it could be inserted into the burrows in such a way as to form a plug. The young insects would then, on hatching from the eggs, have to eat their way through it, and would be killed. It would be a big job in a clearance, though it might be done in a nursery, and would demand careful supervision owing to the poisonous nature of the stuff.

It is not worth while broadcasting the bait yet. Such adults as are present are dying out and only a few eggs will yet have hatched, if any. Later on in November and December, when the

small heaps of fresh earth produced by the young crickets are present in large numbers the land should be hoed and then the poison bait spread. The hoe will kill many. The rest will be driven to feed on the bait, since the jungle has been hoed in.

Doing this will probably save much trouble later, and it would not be a bad plan to bait any place, where crickets are active, directly after the hoe.

The poison is made up as follows :—

| | |
|---|---|
| Husks of rice (*bhusa*), or any green stuff such as chopped up boga medeloa or guinea grass ... ... | 25 lbs. |
| Powdered lead arsenate ... ... | 2 lbs. |
| (or powdered Copper sulphate) | 5 lbs. |
| (Lead arsenate is better) | |
| Lemons ... ... | 6 (finely chopped) |
| (or 12 drops lemon essence) | |
| *Gur* ... ... ... | 3 seers. |
| Water ... ... ... | 4 gallons. |

Mix the *gur* with the water to form a syrup. Add the lemons or lemon essence and stir well. Then stir the lead arsenate into it. Then pour this mixture on to the *bhusa* or green stuff and mix thoroughly. The bait is then ready for application.

As the bait is poisonous to man and animals, special care is required in applying it.

# NOTES ON SOME FUNGUS DISEASES PREVALENT DURING SEASON OF 1922.

A. C. Tunstall, B.Sc.

## Root Diseases.

During the present season specimens of root disease have been received in large numbers. At first sight it would seem from this that these diseases are exceptionally prevalent this year. It is however more probable that the condition of the tea market has had more to do with the increase in the number of specimens sent for report than the prevalence of the disease. There is no doubt however that during the war and the subsequent slump planters paid much less attention to the fungus diseases on their gardens and in consequence small outbreaks were allowed to go unchecked. This has in many cases led to very serious damage and in some instances the disease has become so general that the ordinary simple methods of eradication are impracticable. Since the publication of the pamphlets on root disease a considerable amount of further knowledge has been obtained. There is no doubt however that in the case of small outbreaks of root disease the empirical method of digging out all the dead and diseased roots thoroughly is the most practical way of dealing with it, but in th ecases where the disease has been allowed to spread over a large area something further is necessary.

In order to deal successfully with an extensive outbreak it is essential to thoroughly understand the nature of the disease concerned. The treatment which has been found successful in one case will not necessarily serve for another. It is necessary first of all to get a clear idea of the manner in which the various root diseases are disseminated.

Only one disease, *Hymenochaete noxia*, produced no spores on tea. This fungus sporulates on jungle trees but its fructifications are rare. It follows therefore that it must be distributed by

direct contact. As a rule the disease spreads from root to root below ground but it sometimes proceeds along a trench in which woody material has been buried. Quite small portions of diseased tissue are sufficient to distribute the disease and it is essential to remove all the dead wood from the soil surrounding the bushes which have died of this disease. As a general rule the disease originates in the dead roots of a jungle tree. Sometimes the tree has entirely disappeared above ground before the disease makes itself noticeable on the surrounding tea. In our own tea plots at Tocklai this disease occurred in a place which had been grazed over for years. A careful search in the soil, however, revealed portions of a Nahor tree root some feet below the surface. There is only one way to treat this disease, the dead wood must be completely removed as quickly as possible. The disease is specially prevalent on sandy soils. No soil treatment seems to do any good. Unfortunately complete removal takes a lot of time and labour and in the case of large areas the treatment cannot be carried out at once. In such cases the implements used for cultivating the infected areas should be kept separate and operations for the eradication of the disease should be carried out as rapidly as possible round the edges of the patches, the centres being left until labour is available to complete the work. In this manner the disease may be prevented from extending but the bushes still uninfected within the area are not protected. To protect them a trench deep enough to isolate their roots may be dug.

*Ustulina zonata* spreads from root to root just like *Hymenochaete noxia*. Unfortunately this fungus also spreads above ground by spores. These spores can only attack the plants at decaying wounds such as dead snags on borer holes. As the disease spreads above as well as below ground the treatment suggested for *Hymenochaete noxia* does not apply. When a section is badly attacked the disease is often distributed here and there over a large area and is not confined to one or two large patches. In the case of neglected outbreaks when the fungus has attacked very many plants it is impossible to remove all the plants at once. It is necessary to find some method of rendering the remaining healthy plants temporarily less susceptible to the

disease. As the disease is principally found on acid soils removal of the acidity may help matters. It has been found that heavy dressing of lime have this effect and whenever this disease appears a heavy dressing of lime should be applied to the soil in the neighbourhood of the diseased plants. The dead plants should be removed as soon as possible and all the remaining bushes should be carefully cleaned of all dead snags and the wounds painted with a mixture described below.

Other root diseases resembling *Ustulina zonata* in their effects are occasionally found. One caused by *Kretzschmaria rhizopus* very much resembles *Ustulina zonata* in appearance as well as in its effects. On some deteriorated bheels the tea has become infected with a fungus called *Auricularia Judiae*. This fungus enters the plants at dead snags and after growing through the woody tissue finally attacks the growing layers and kills the plant usually branch by branch. The fungus produces a fruit resembling a brown human ear hence the name Jew's ear fungus. The treatment suggested for *Ustulina zonata* is equally applicable to this fungus.

*Sphaerostilbe repens* spreads in a similar manner to *Ustulina zonata*, but it is much more susceptible to soil treatment. It is a disease which will only thrive in water-logged acid areas. It has been found that bushes already badly infected will often recover if these conditions are removed. Areas infected by this disease should be heavily limed and the drainage improved as much as possible. All dead plants should of course be removed as soon as convenient.

*Rosellinia arcuata.* This disease is distributed by spores and by spreading through dead organic matter from bush to bush. It does not readily attack healthy clean stems or roots but generally starts in dead decaying snags or in collections of dead leaves lying in contact with the bushes. It also grows in dead wood buried in trenches. The fungus is particularly susceptible to the action of lime and in most cases the disease can be checked by liming the soil and laying bare the collars of the bushes in the neighbourhood of the diseased ones. Where trenches

have become infected it is neeessary to dig out all the infected material. This is a long job and it is suggested that on areas where this disease has been found the trenching material should be sprinkled with lime before being covered up. It is also as well not to make the trenches continuous. In that case if a trench becomes infected comparatively little work will be required to remove all the infected material.

*Thyridaria tarda* is probably the most widely distributed of all the fungi which may be termed root fungi. This fungus is present throughout the tea districts but fortunately it only does serious damage under exceptional circumstances. The fungus attacks plants through wounds and spreads throughout the wood causing very little damage to healthy vigorous plants. If however the vitality is lessened for any reason the fungus attacks the layers actively concerned in growth and a moribund condition of the plant results. Plants in this condition succumb to Red Rust, Brown Blight and other diseases. In a few cases the plant dies very suddenly for no apparent reason. This sudden death often occurs after pruning. Bushes which have been moribund for a long time sometimes recover completely when conditions are improved. Drought is one of the commonest conditions rendering plants susceptible to this disease and it is always most prevalent on coarse sandy soils. When tea growing on such soils is cut back or collar pruned this disease often causes much damage. The fungus most readily attacks the cut ends of branches when the wood is drying back. When the soil is deficient in moisture, the cuts do not heal so readily and there is a tendency for them to dry. They are then specially susceptible to this fungus. For this reason it is well to do all heavy pruning very early on such soils and to protect the wounds by a mixture described below. This method has been found very satisfactory on a number of gardens. On most areas of cut back some of the plants do not come away. In many cases their failure is due to *Thyridaria tarda*. It has been found that the application of *2* to *3* ozs. of Nitrate of Potash to the soil round each of these bushes frequently gives them the start. The same treatment applied to moribund bushes is often sucessful but in the case of unpruned

or light pruned bushes in this condition it is desirable, in addition, to spray the plants about April with a fungicide *e. g.*, Lime sulphur solution to help them to withstand the attacks of Red Rust and Brown Blight which almost invariably attack them severely. In the case of collar pruned bushes which fail to come away the topmost layer should be cut off and the fresh cut painted over, in addition to the Nitrate of Potash manuring. Briefly it is desirable to carry out the pruning when the wounds are likely to be least susceptible to the fungus and further to protect the wounds immediately from the fungus. For the past two years observations have been made at Tocklai of the spores present in the air at varying distances from the nearest tea. It was found that spores of this fungus were less frequently found about September and October although the wind at that time was blowing from the direction of the tea. For this reason also it would seem desirable to prune early. The fungus may also attack the bushes on the roots where the hoe has cut them. This has been noticed in many cases at Borbhetta. To treat the bushes which show signs of the disease by becoming moribund the application of Nitrate of Potash is recommended aided, if necessary by spraying. Dead bushes should be removed as soon as possible as the spores of the fungus are produced in profusion on the dead roots. Although the fungus is always present it is of course desirable to reduce the number of spores available as much as possible.

### Dead wood usual source of infection.

From a study of root disease as a whole a few general conclusions may be drawn. With the exception of *Thyridaria tarda*, which is not properly a root disease, these diseases spread principally below ground and any dead wood in the soil is liable to prove a centre of infection. On gardens planted out on Forest land there are generally plenty of tree stumps among the tea and any of these stumps is dangerous. It is quite useless to compile a list of the trees specially liable to start root disease as no woody tree appears to be immune from attack. The burial of woody material in trenches is always likely to lead to trouble unless the wood is sprinkled with lime. This seems to hasten decay and at the same

time prevent the attacks of fungi causing root disease. If a root disease fungus attacks this wood it may be necessary to dig it all out. This is a very expensive operation, but it has had to be done in some cases. Wherever the root disease is prevalent it is wise to break the continuity of the trenches at intervals to limit the extension of any pathogenic fungus which might attack the trenched in material.

When the disease producing fungus is able to spread above ground, dead wood, in the shape of decaying snags, is again the principal consideration and all such should be carefully avoided. Many bheel gardens have bushes covered with snags and if the soil conditions become unfavourable the spread of such a fungus as *Auricularia Judiae* is greatly facilitated. This has been frequently illustrated on deteriorating bheels. The deterioration is in the first place due to soil conditions and the fungi complete the bad work.

*Soil conditions.* In the case of all root diseases the soil conditions largely determine the susceptibility of the bushes to attack. Most fungus diseases of this nature thrive best on acid soils. The mechanical condition of the soil is of special importance in the case of *Sphaerostilbe repens.* A stiff soil difficult to drain is generally infected with this fungus. It seems that heavy applications of lime tend to make the soil unfavourable to the fungus. The lime besides removing acidity and improving tilth also expedites the decay of dead wood. There is no doubt that much can be done by manuring to render the bushes themselves less susceptible. For instance the action of Potash on the bushes infected with *Thyridaria tarda* on sandy soils. The problem of the influence of soil on the susceptibility of the plants growing thereon to fungus disease or insect attack is a very complex one and further chemical investigation is necessary before definite recommendations can be made.

*The danger of delay.* Root diseases except *Thyridaria tarda* can be controlled by the simple method of carefully removing the diseased plants Immediately the disease is noticed. This method is easily carried out when the outbreak is small, but if small

outbreaks are neglected the disease in question very soon becomes so serious that treatment is very expensive and laborious. In any case sooner or later the dead roots have to be removed and the cost of treatment alone may be very heavy. The loss due to root diseases is enormous and in many cases can be prevented by taking precautions in time. Whenever a plant dies from any cause it should be removed at once. If the cause is unknown the dead plant should be sent to this department with full particulars of the circumstances in which it died. An idea should be given of the severity of the attack. It often happens that a diagnosis cannot be made immediately. If the fungus has produced no fructifications it is often impossible to identify it with certainty and cultures, etc., have to be prepared in order to obtain fructifications. This takes time, perhaps some months. Where the attack shows signs of becoming serious preference may be given to such cases so that further treatment may be delayed as little as possible. No bushes should be regarded as having died from mechanical injury. In all cases disease should be presupposed.

### Paint for treating wounds.

A simple and effective fungicidal paint for painting wounds is made as follows. Dissolve 5 lbs. of Copper sulphate in 10 gallons of water and add to this slaked lime in sufficient quantity to make a paste. The use of rice water instead of ordinary water makes the paste adhere better.

### Black rot.

During the past few months a number of outbreaks of a serious disease called Black rot have occurred in Assam. This disease is caused by a fungus *Hypochnus theae*. This fungus possesses a very fine mycelium which grows on the outside of the plant like Thread blight. The threads are so minute as to be almost invisible to the naked eye. Even with a lens they are often difficult to distinguish. The fungus attacks the green shoots and leaves. At first it causes a slight discoloration which rapidly becomes darker. When wet the dark patches are almost black, but on drying they resemble those formed by Brown Blight. Sometimes

the patches become infected by Brown and Grey Blight and the true nature of the disease is often masked by this. One of the characteristics of this disease is the manner in which the leaves stick together wherever they touch. It is also noticeable in many cases that the disease occurs in patches on the bushes not like Brown Bight which is scattered all over a bush. The spores are produced on the undersides of the leaves usually on healthy looking green portions. The spore producing area is white, just as though a little dusting powder had been sprinkled on the surface of the wet leaf. The spores are basidiospores and are produced on the ends of hyphæ projecting from the mycelial net. Fortunately in most cases only few patches of spores are to be found and the disease is distributed more by contact than by spores. Coolies working in the infected tea brush off little bits of the mycelium and thus transfer it from bush to bush. When spores are being produced the spread of the disease is much more rapid and infected bushes are found scattered all over a section instead of in patches. The disease is capable of doing very severe damage. On one garden a considerable area of tea has been so severely damaged that a large number of bushes have died right out and the yield of some hundreds of acres considerably reduced. Unfortunately the presence of this disease was not suspected for a long time. The deaths of the bushes had been attributed to root disease and the brown spots on the leaves to Brown Blight. Some years ago a serious outbreak of this disease occurred in a garden in Upper Assam and the writer personally supervised the treatment. This work was reported in the *Quarterly Journal*, Part III, 1918. The results of this treatment were very satisfactory.

### Isolation.

When this disease is suspected the area of tea infected should be isolated at once. All the coolies necessary for the cultivation, etc., should be specially selected and not allowed to work in the other tea without being disinfected. The simplest method of carrying this out is to spray the coolies with Lime—sulphur solution as they leave the work. This solution in the strength suitable for spraying tea does not injure the skin or clothing. It

hurts the eyes but it is unnecessary to spray the face. The smell is unpleasant but coolies do not object to it. It may also be pointed out that this solution is a remedy for itch and other skin diseases. The implements, baskets, etc., should also be treated the same way.

### Treatment.

The diseased leaves and shoots should be removed and burned. The plants should then be thoroughly sprayed with Lime—sulphur solution. The spraying should be repeated a week or ten days later.

If the disease has spread over a large area, treat all the small patches in the tea showing least infection, including in the treatment three rows of bushes all round the diseased ones. Meanwhile keep the large areas isolated and treat these later as soon as time permits.

As the fungus is wholly outside the plant like Thread Blight it is possible to kill it right out with a spray fluid. A second application is only recommended in case some parts of the bushes have been missed in the first application.

When sending specimens suspected of having Black Rot to the Scientific Department it is advisable to send them packed in a corked bottle as when the specimens are dried up this disease it is very difficult to identify.

# NOTES.

**"The Use of Flowers for Infusing"**—The following appears in the International Review of Science, No. 9, Year XII, as an abstract of an article in the *Boletin de Agricultura Industria y Comercio de Guatemala.* Year I, p. 23.

The infusion of the flowers of tea is much less known than the infusion of the leaves, although richer than the latter in aroma and equal to it in all other qualities. In view of the facility for fraud in the leaf-tea trade, the flowers offer several advantages compared with the leaves, *e.g.*, easy plucking, no injury to the bush, much greater difficulty in adulteration.

As the tea bush flowers very abundantly, it would be profitable to work it for its flowers. Tea made from the flowers could be sold at a higher price than that made from the leaves, for not only is it more aromatic but also sweeter and contains less thein. Recently tea made from the flowers, which up to date had been reserved for the exclusive use of the rich people in the principal producing countries, and was not exported, has begun to be imported into Europe.

Tea does well where coffee does well ; its growth in Guatemala, with a view to harvesting the flowers, is therefore recommended.

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